

A Pulsed 2-micron Coherent Differential Absorption Lidar for Atmospheric CO₂ Measurements

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*Laser Applications to Chemical, Security and Environmental Analysis
January 31, 2012*



Outline

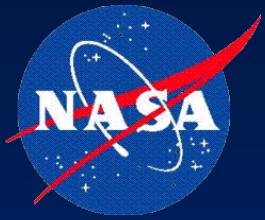
- 2-micron Pulsed Lidar Approach for CO₂ Measurement
- High Energy 2-micron Pulsed Lidar- for Mobile Ground and Airborne CO₂ Profiling
 - Double Pulse Laser Transmitter for DIAL
 - High Accuracy Wavelength Control and Switching
 - Ground Based High Energy Coherent CO₂ DIAL Demonstration
- Summary



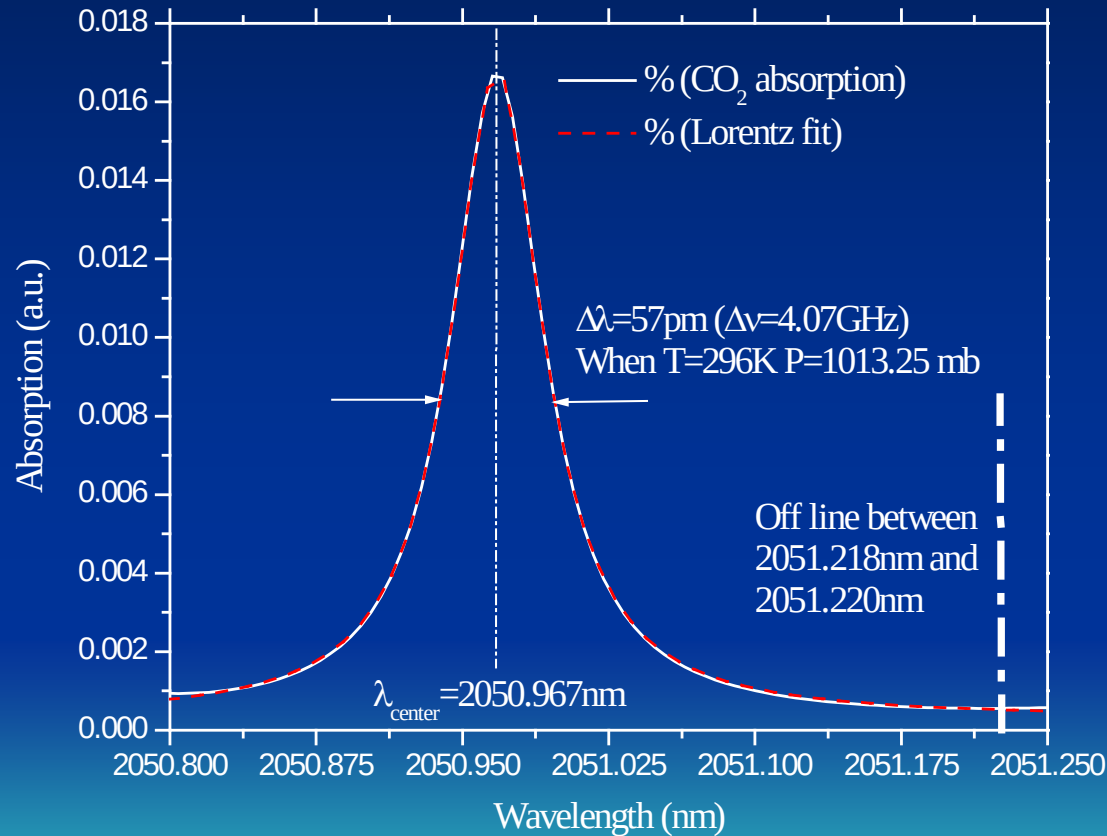
Pulsed Lidar Approach

- A CO₂ profiler from ground or airborne platform is an indispensable validation tool for ASCENDS mission
- For column measurements, the pulsed lidar approach can eliminate contamination from aerosols and clouds to yield high accuracy measurements
- The pulse approach can determine CO₂ concentrations as a function of distance with high spatial and temporal resolution, a valuable data product that is not currently available
- The weighting function in the 2- μ m region is most favorable for making CO₂ measurements near the surface and PBL, where the sources and sinks of CO₂ are located

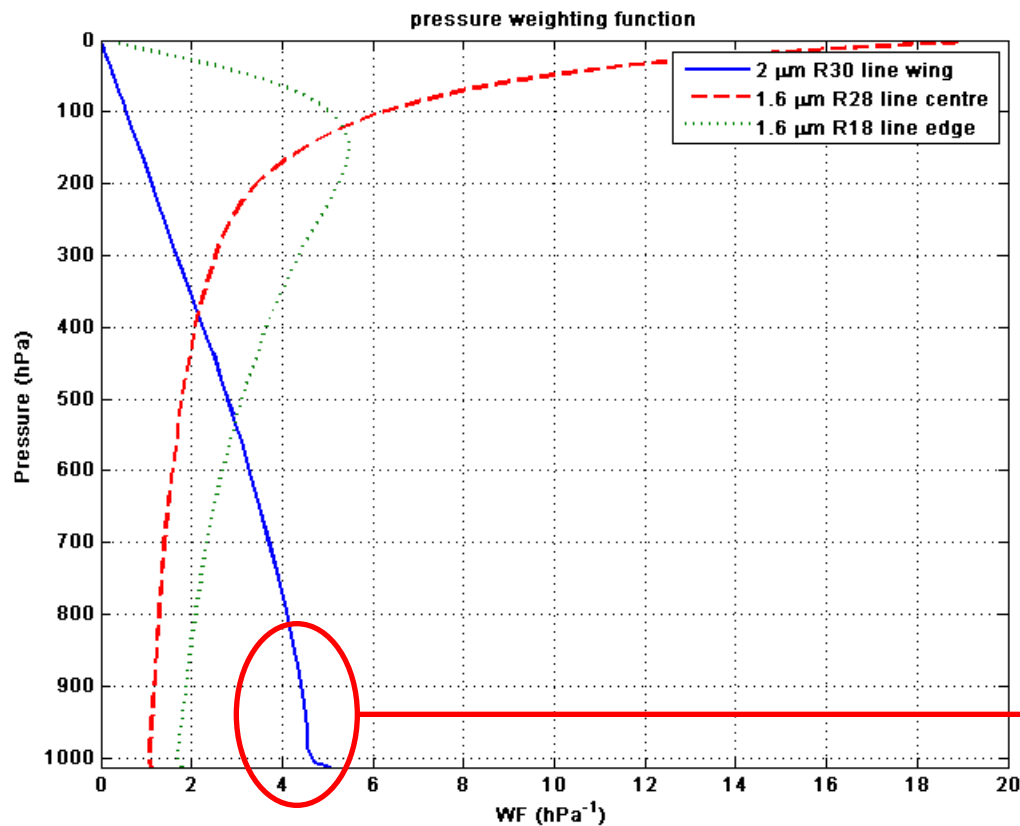




Differential Absorption (R30 line)



Requirement on high sensitivity of the WF to the lowest atmosphere

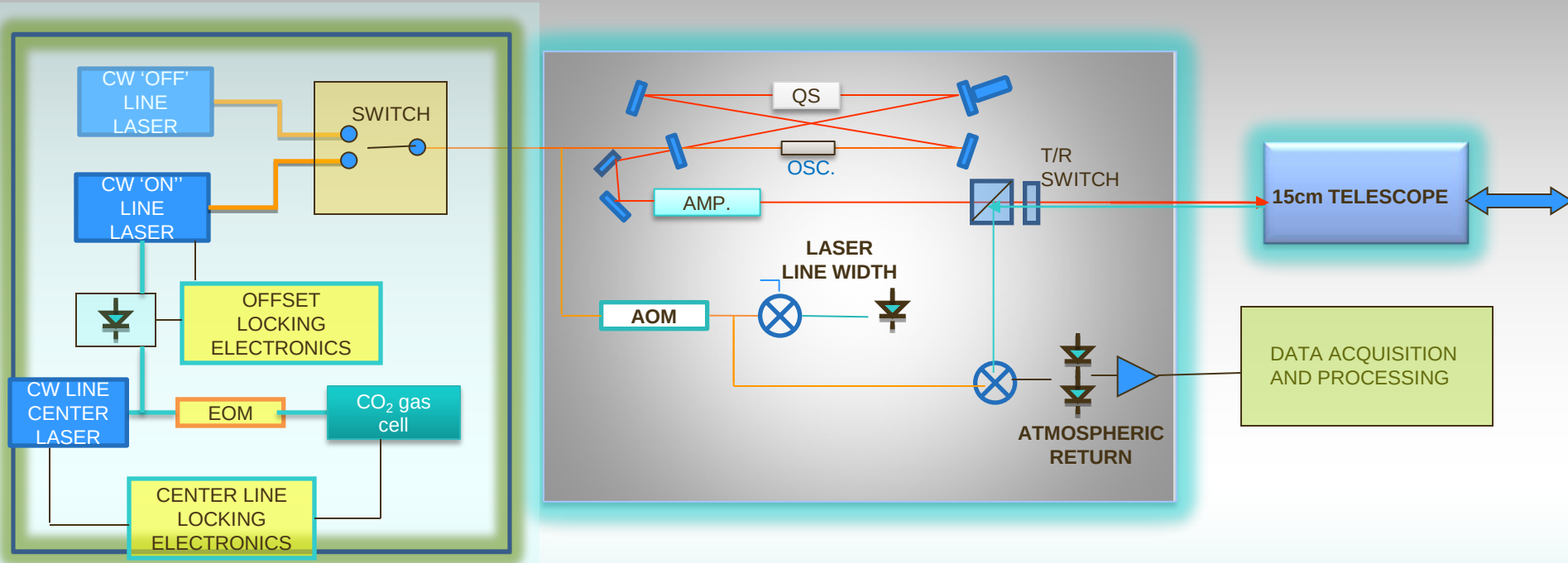


Selection of the R30 CO₂ absorption line at 2050.967 nm in the $(20^0 1)_{III} \leftarrow (00^0 0)_I$ band of CO₂ as one of the most suitable line for DIAL measurement from space.



Weighting function peaking in lowest part of atmosphere

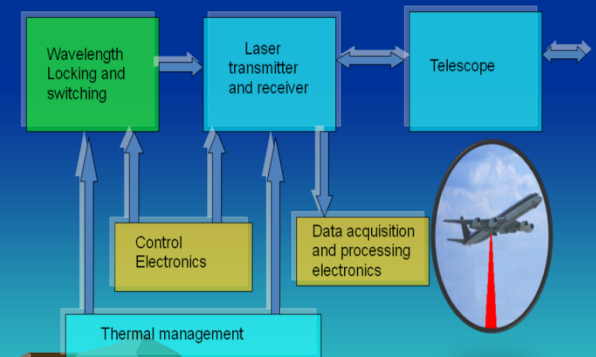
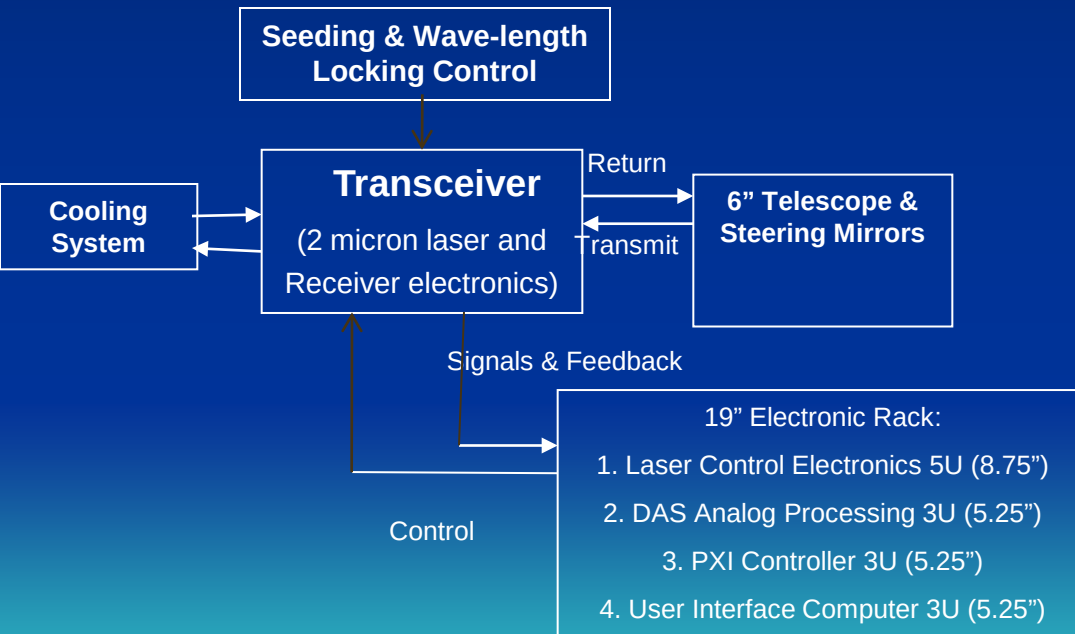
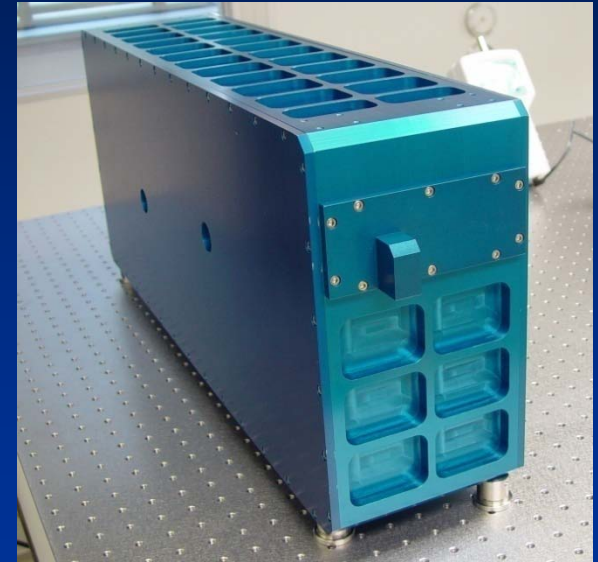
Coherent DIAL Instrument Simplified Schematic



Pulsed Coherent CO₂ DIAL

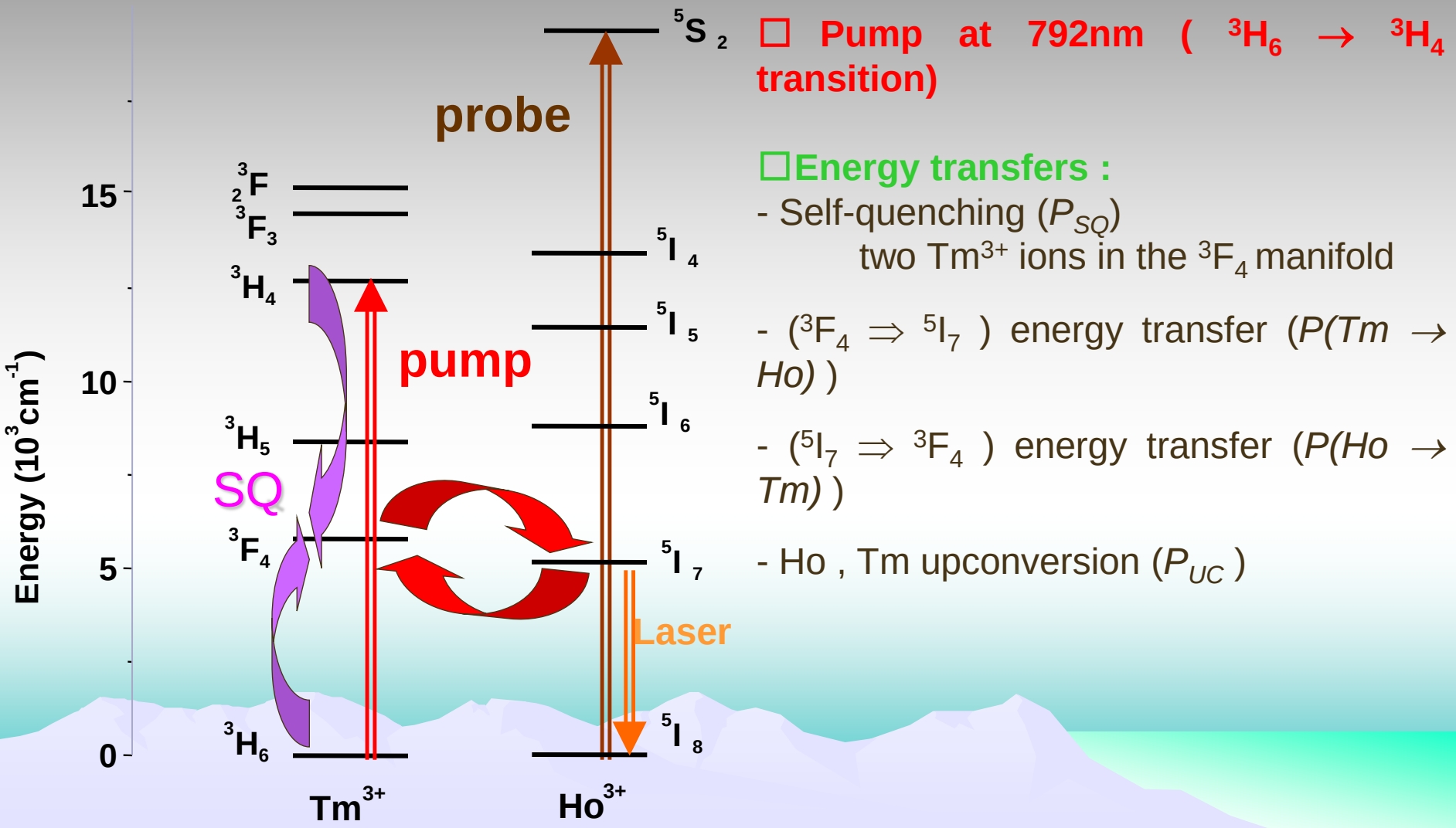
- Pulsed 2-micron laser transmitter
 - 250 mJ/10Hz
 - Coherent DIAL

- Provide CO₂ profiling/column density measurement

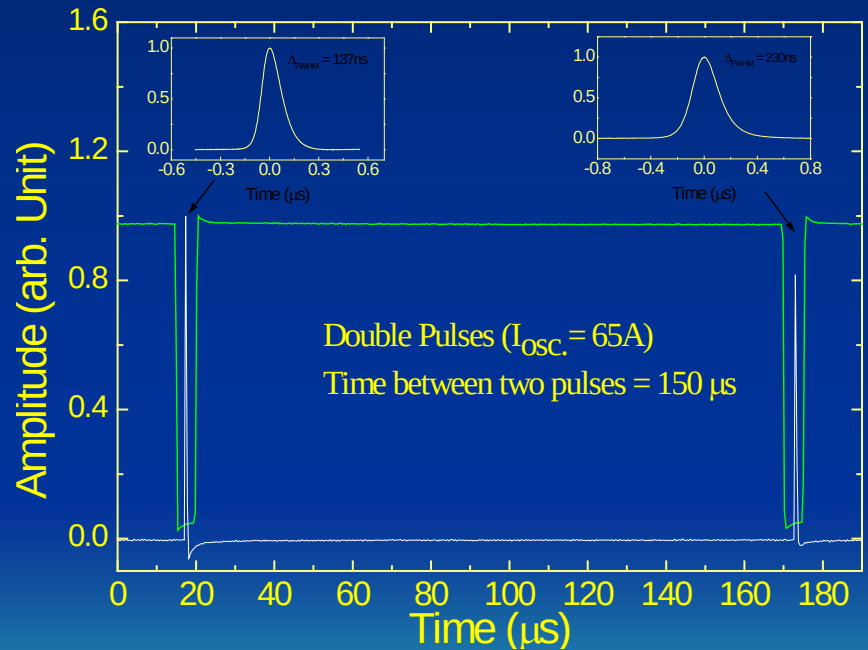
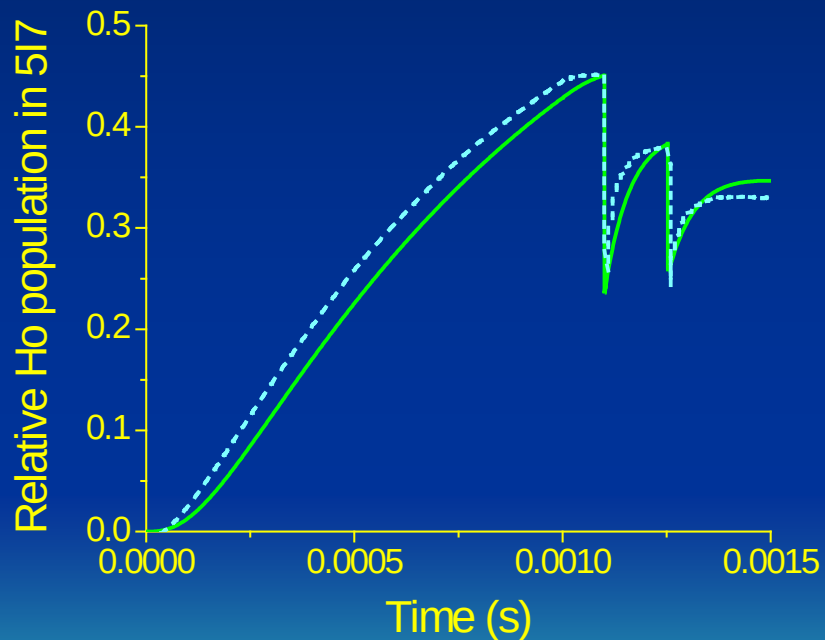


- Compact and ruggedized package
- Prototype has been demonstrated with optimization and packaging remaining
- Prototype has been demonstrated with modification and optimization remaining

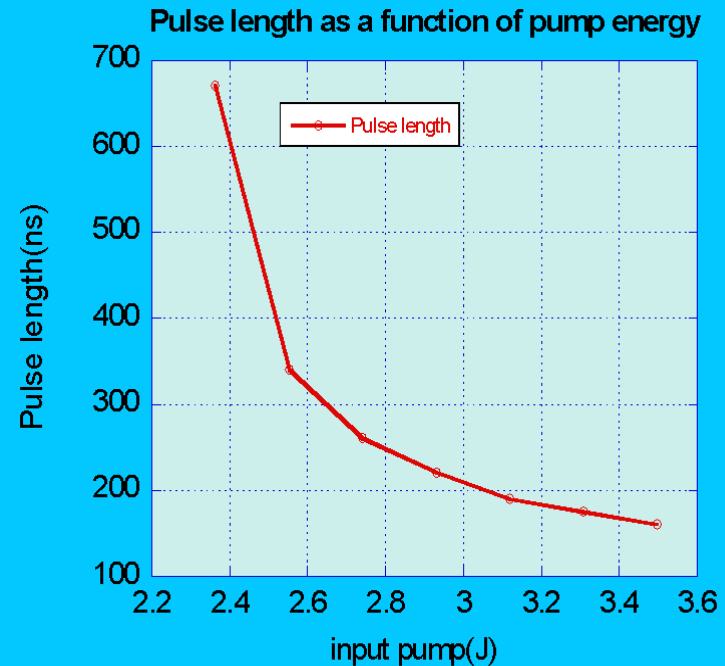
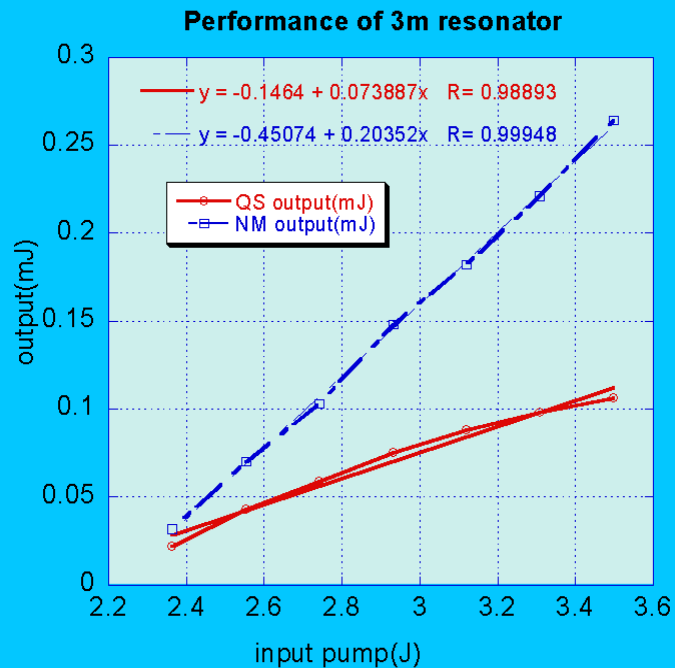
Energy transfers between Ho^{3+} and Tm^{3+} ions and Pump-probe experiment



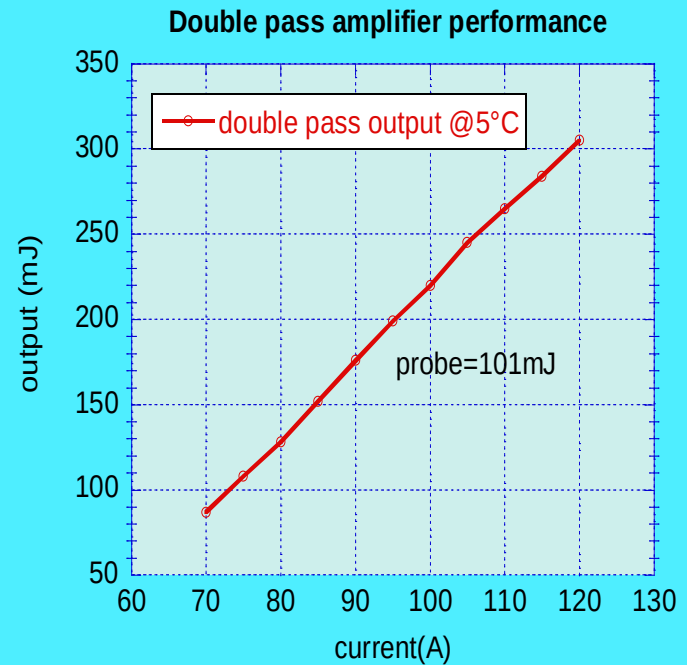
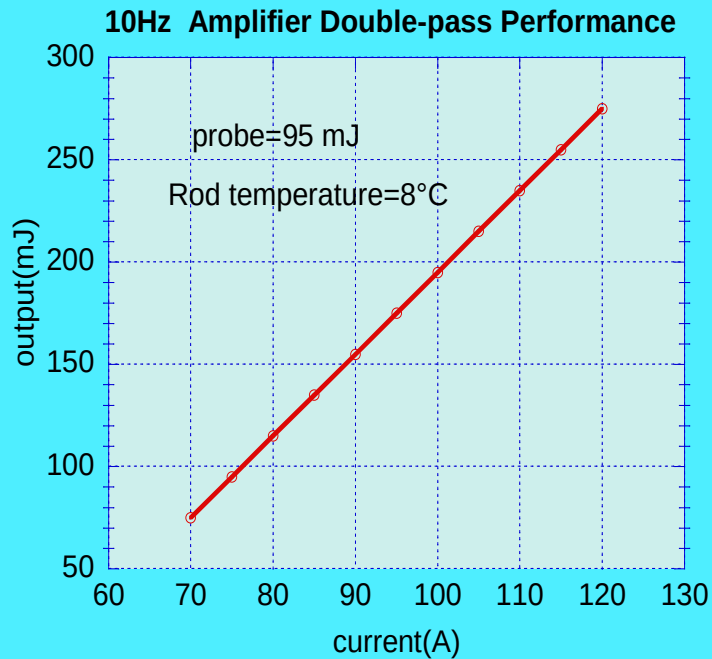
Double pulsed 2- μm laser operation



10Hz Oscillator Performance



Double Pass Amplifier Performance



Amplifier gain: double pass ~3

Laser Beam Profile

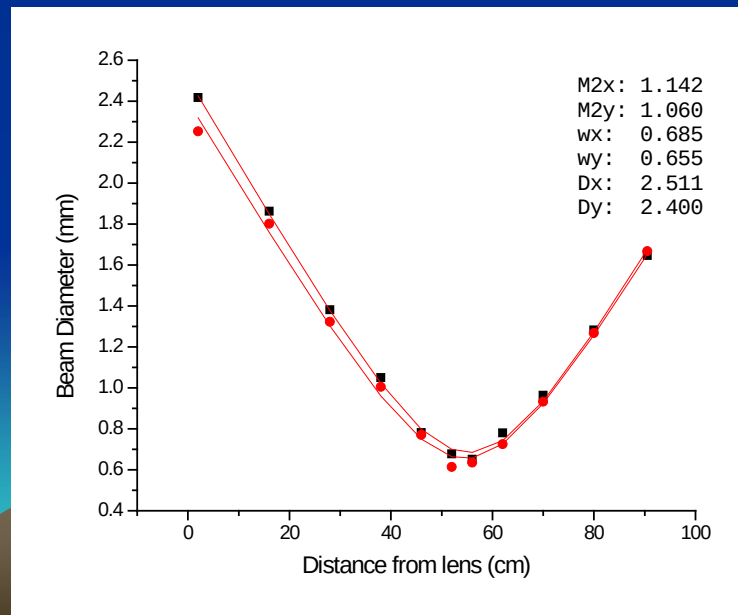
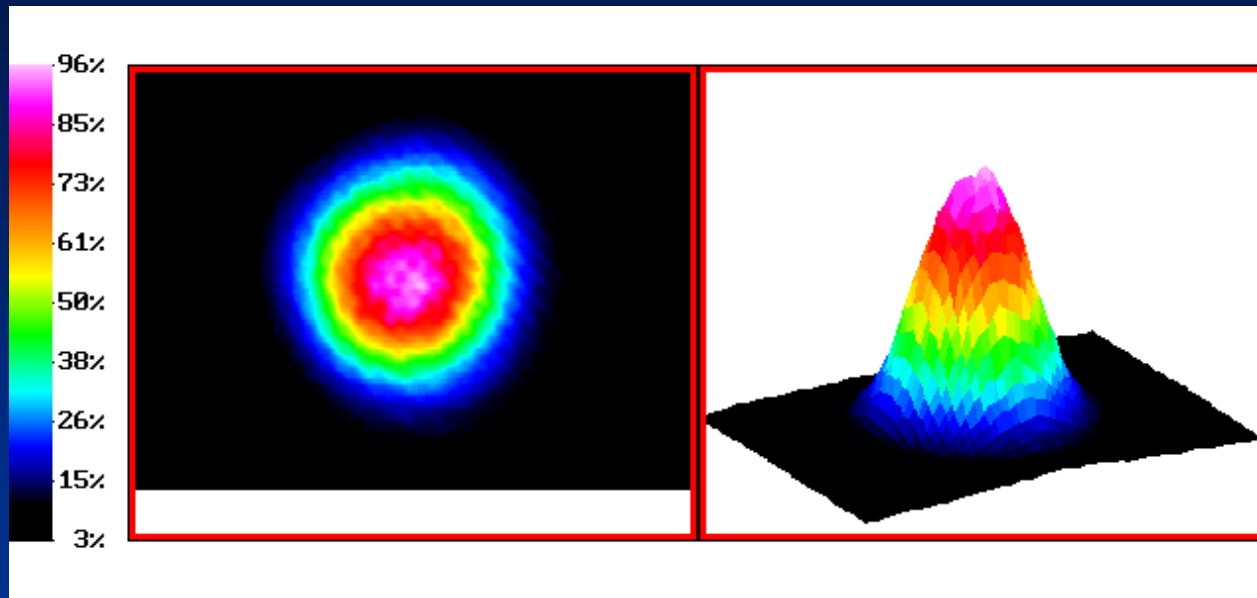
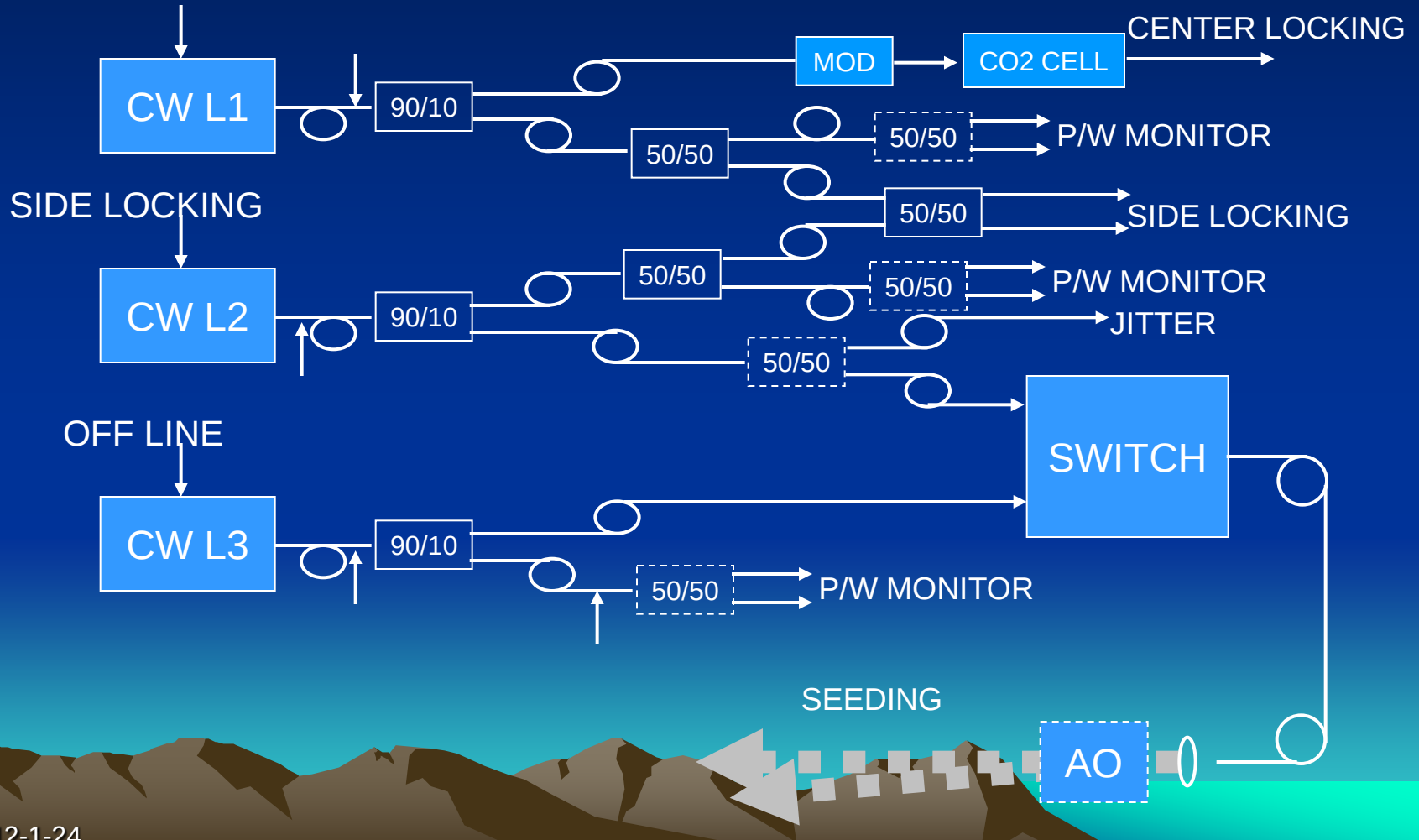
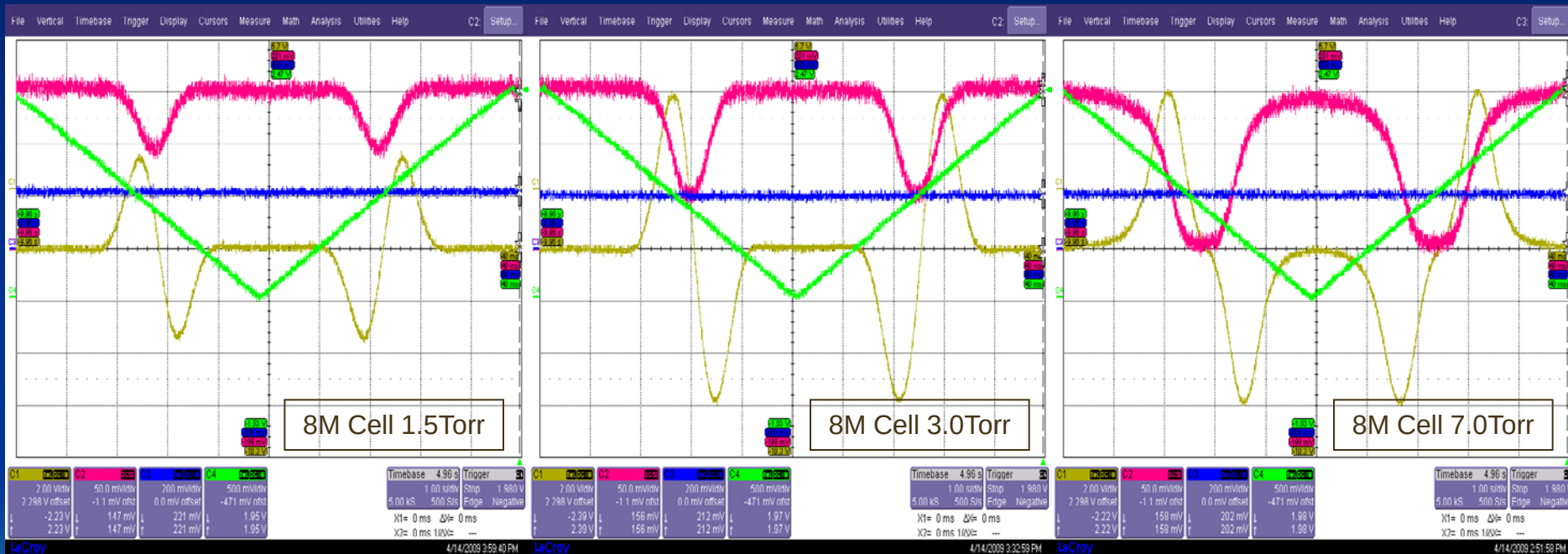


DIAGRAM OF BREADBOARD SEEDING LASERS

CENTER LOCKING



FREQUENCY LOCKING AT CO₂ ABSORPTION LINE CENTER ---- ABSORPTION & LOCKING CURVES



8M Cell 1.5Torr

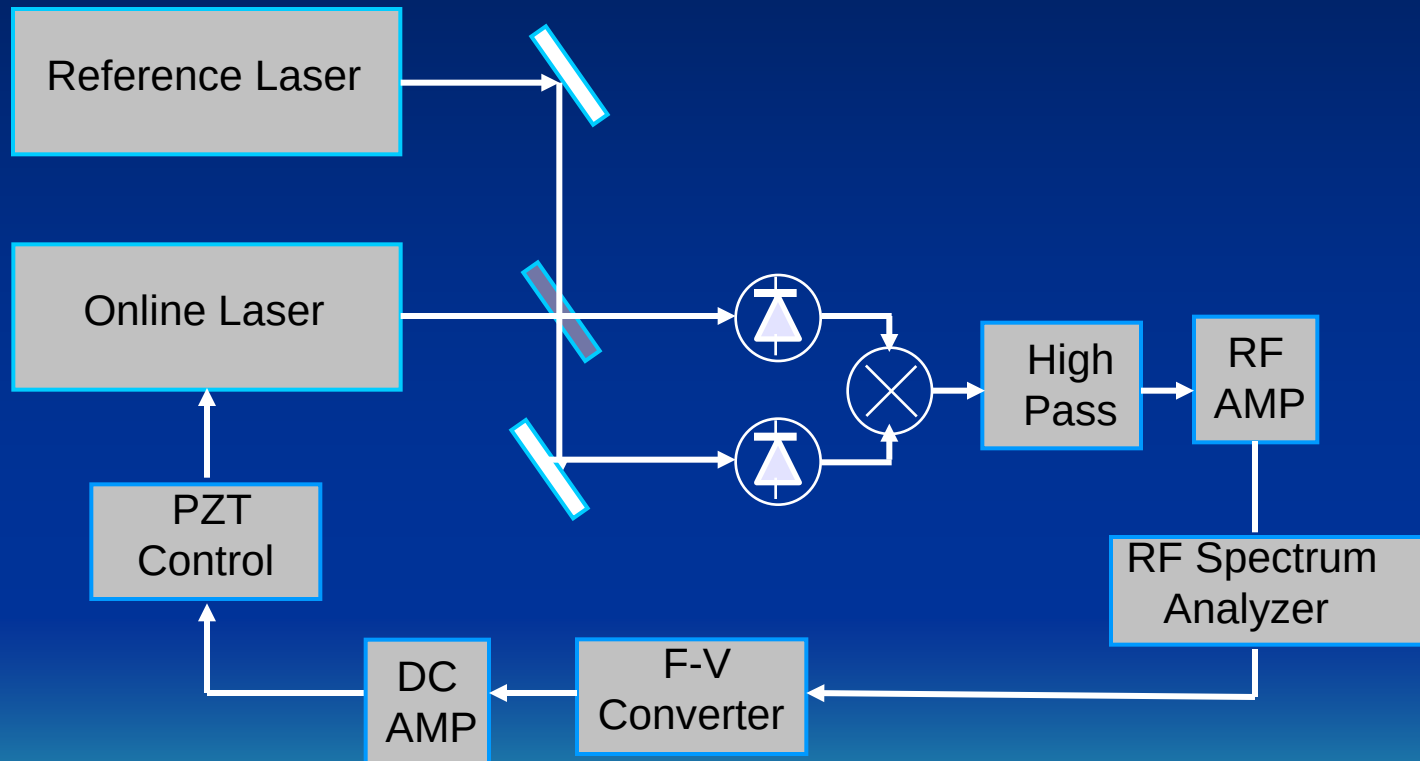
Scanning

Normalization

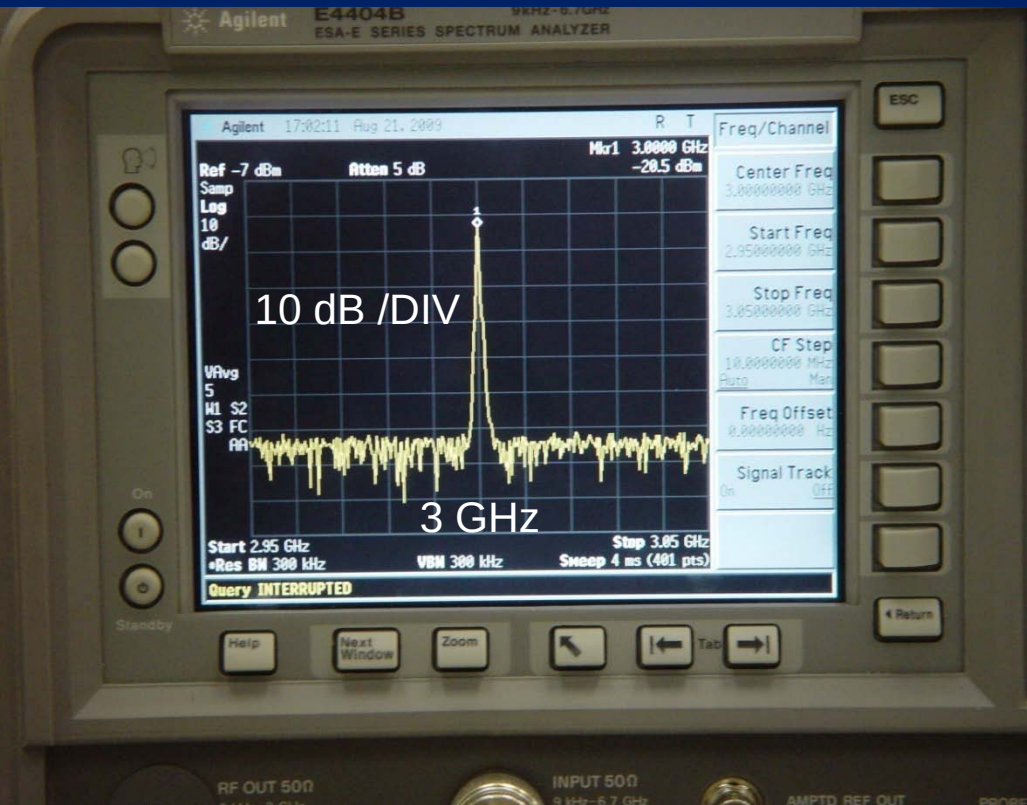
Absorption

Locking

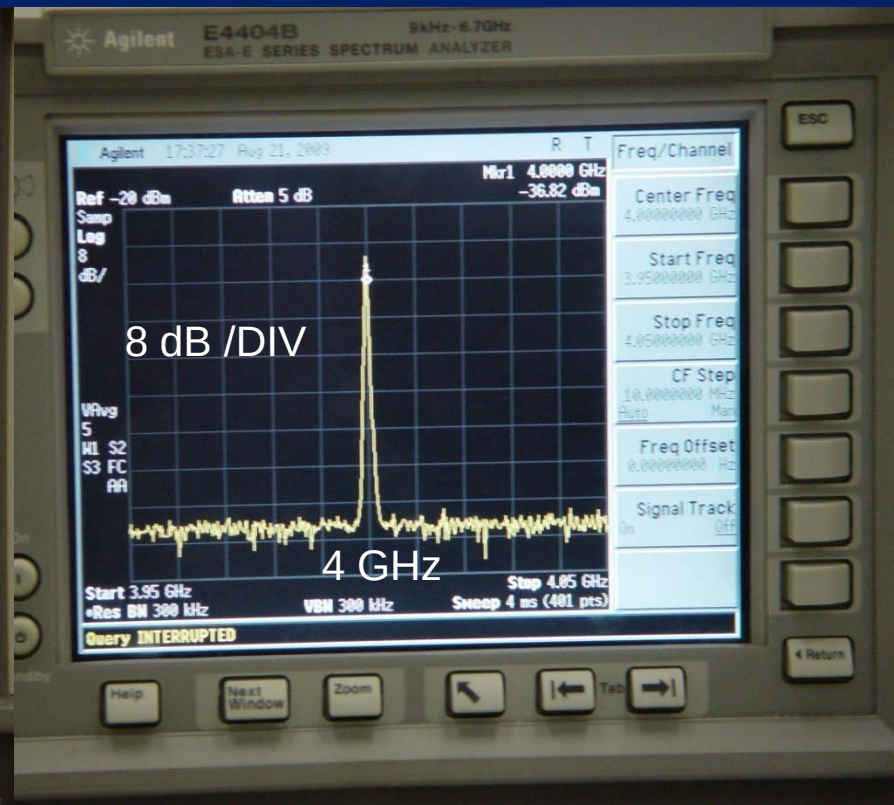
FREQUENCY LOCKING AT CO₂ ABSORPTION LINE WING ---- PRINCIPLE & DIAGRAM



FREQUENCY LOCKING AT CO₂ ABSORPTION LINE WING ---- BEATING SIGNALS ON ESA

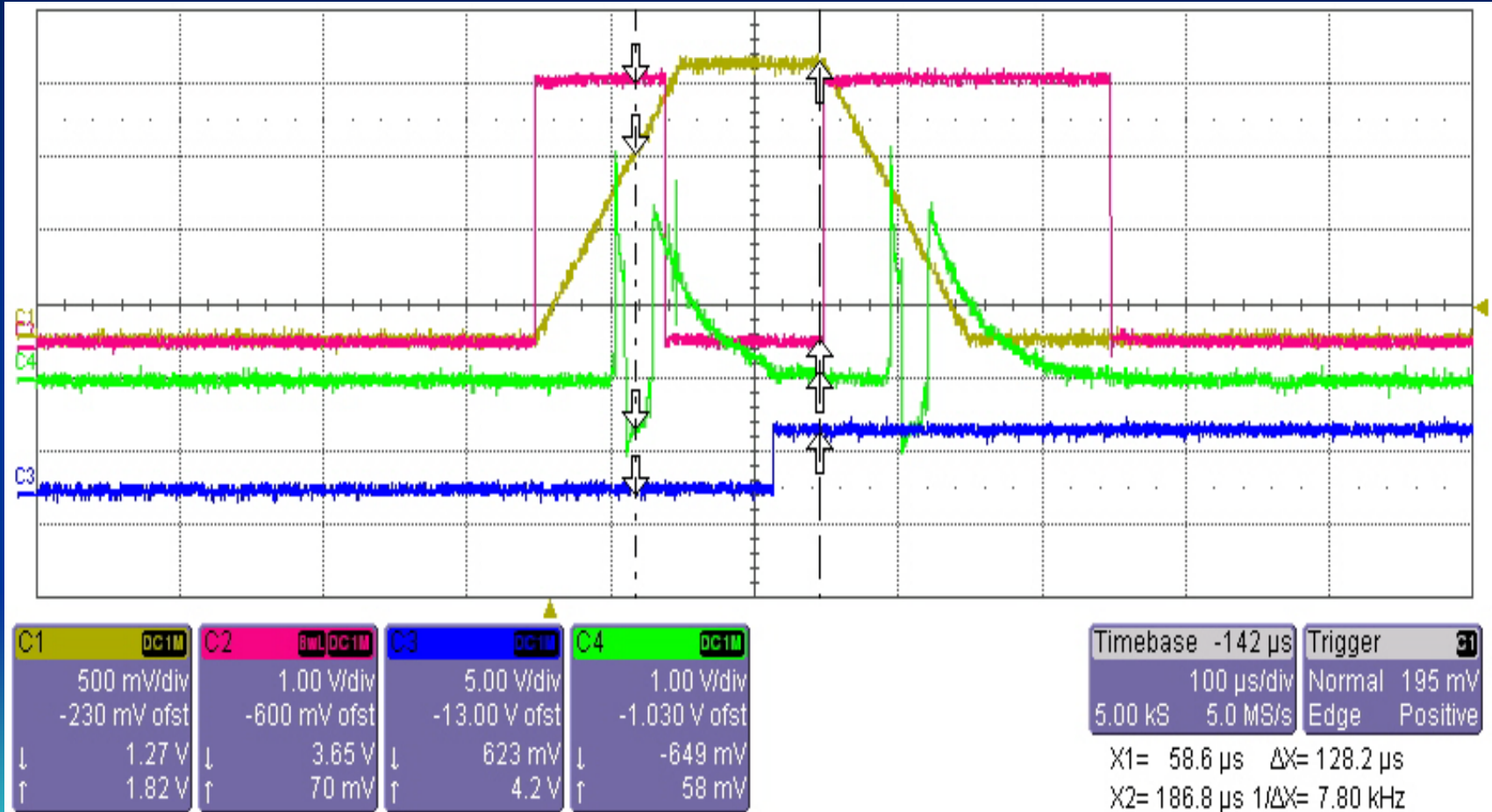


3 GHz BEATING SIGNAL

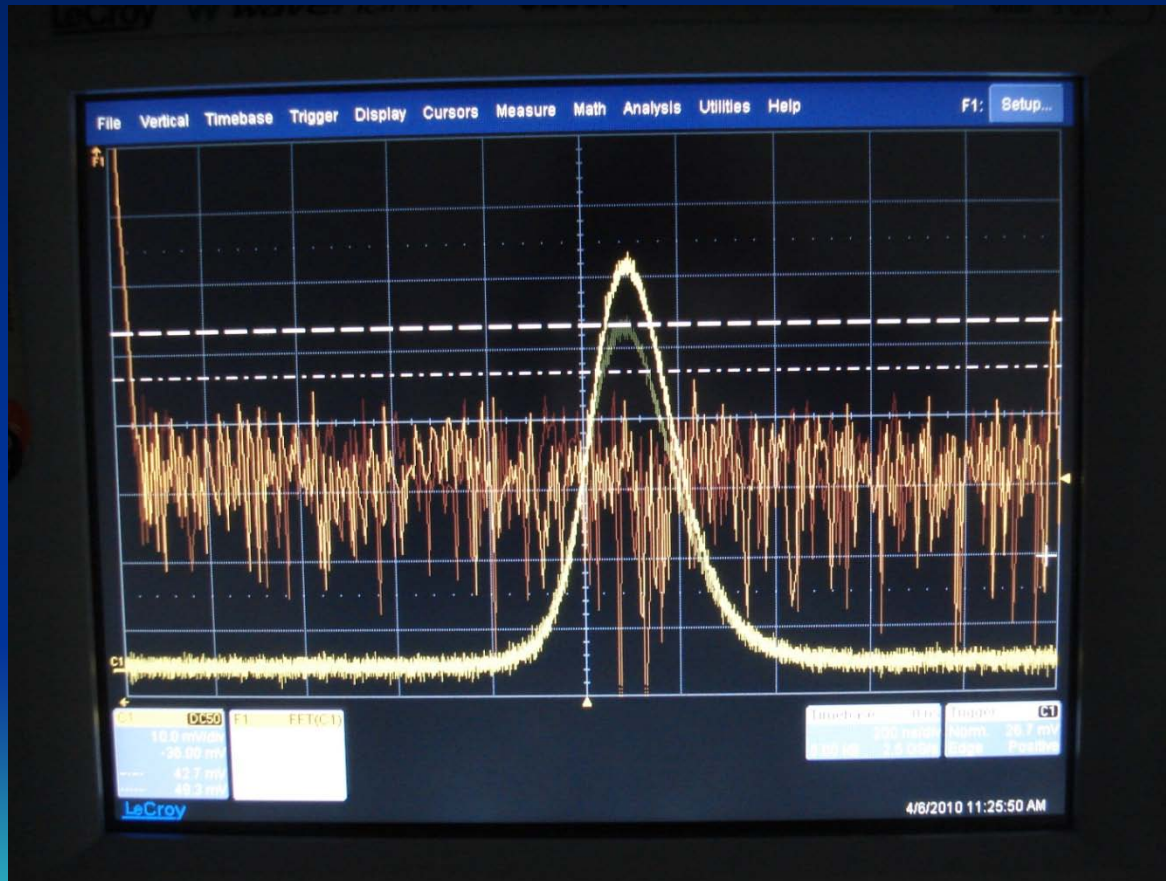


4 GHz BEATING SIGNAL

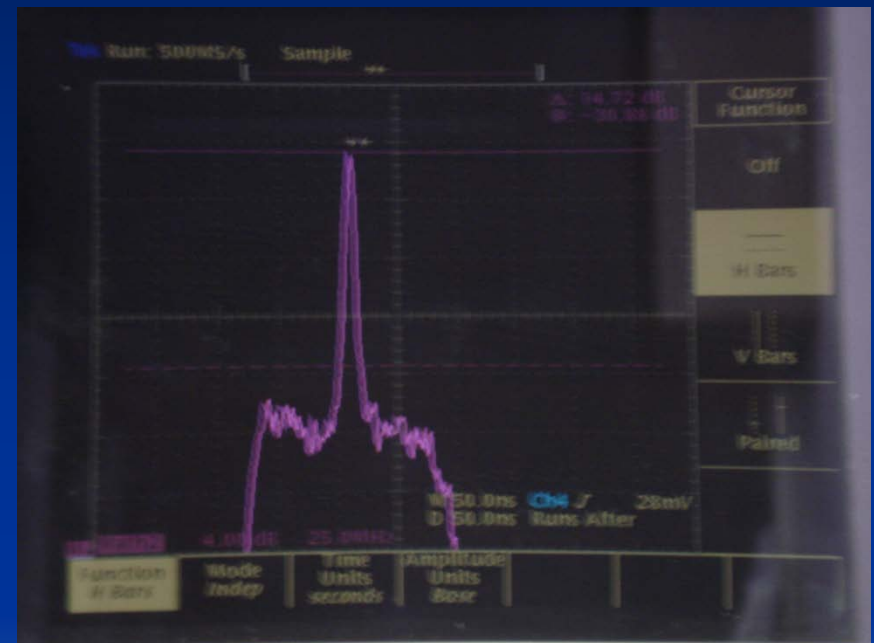
Double Pulse



Single Frequency

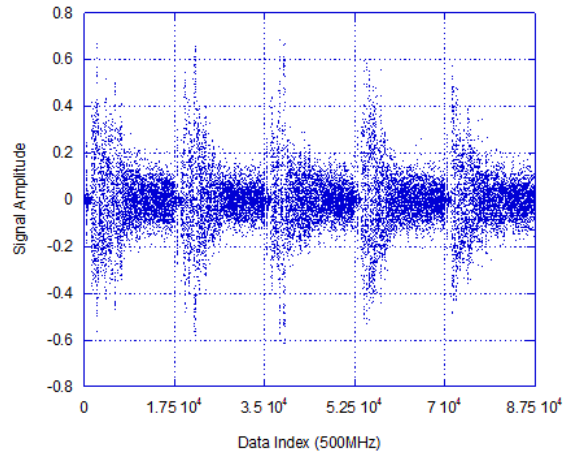


Atmospheric Return Signal

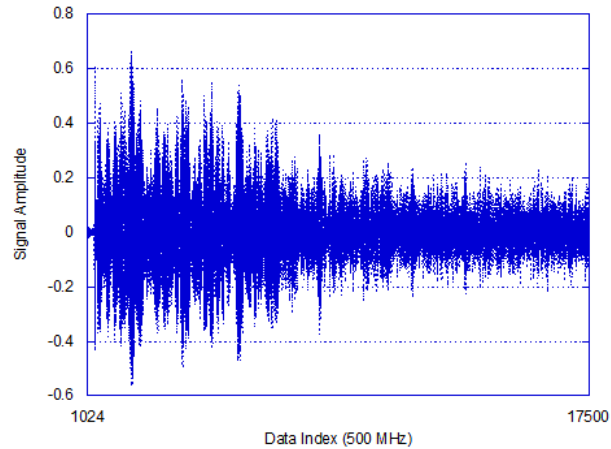


Lidar Signals

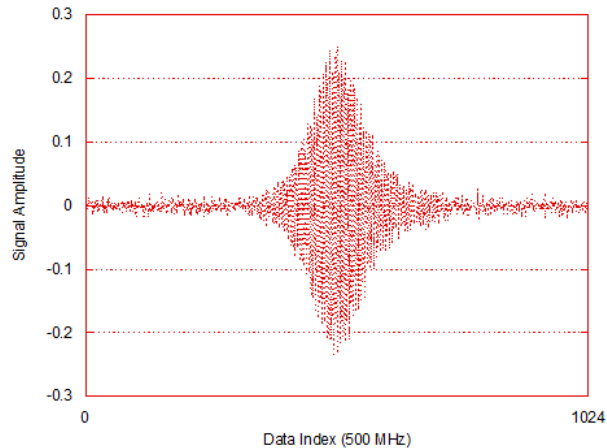
Channel 1 - Pulse Waveforms



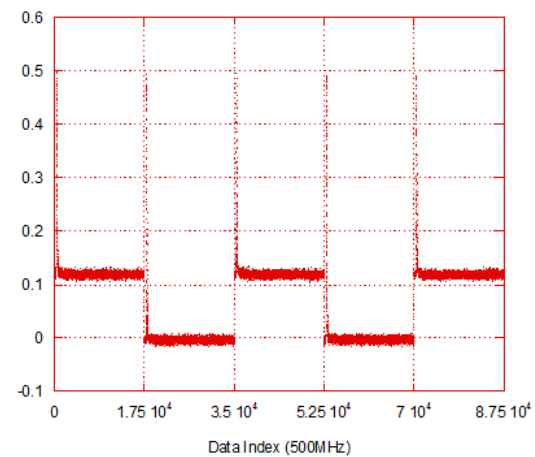
Channel 1 - Individual Pulse



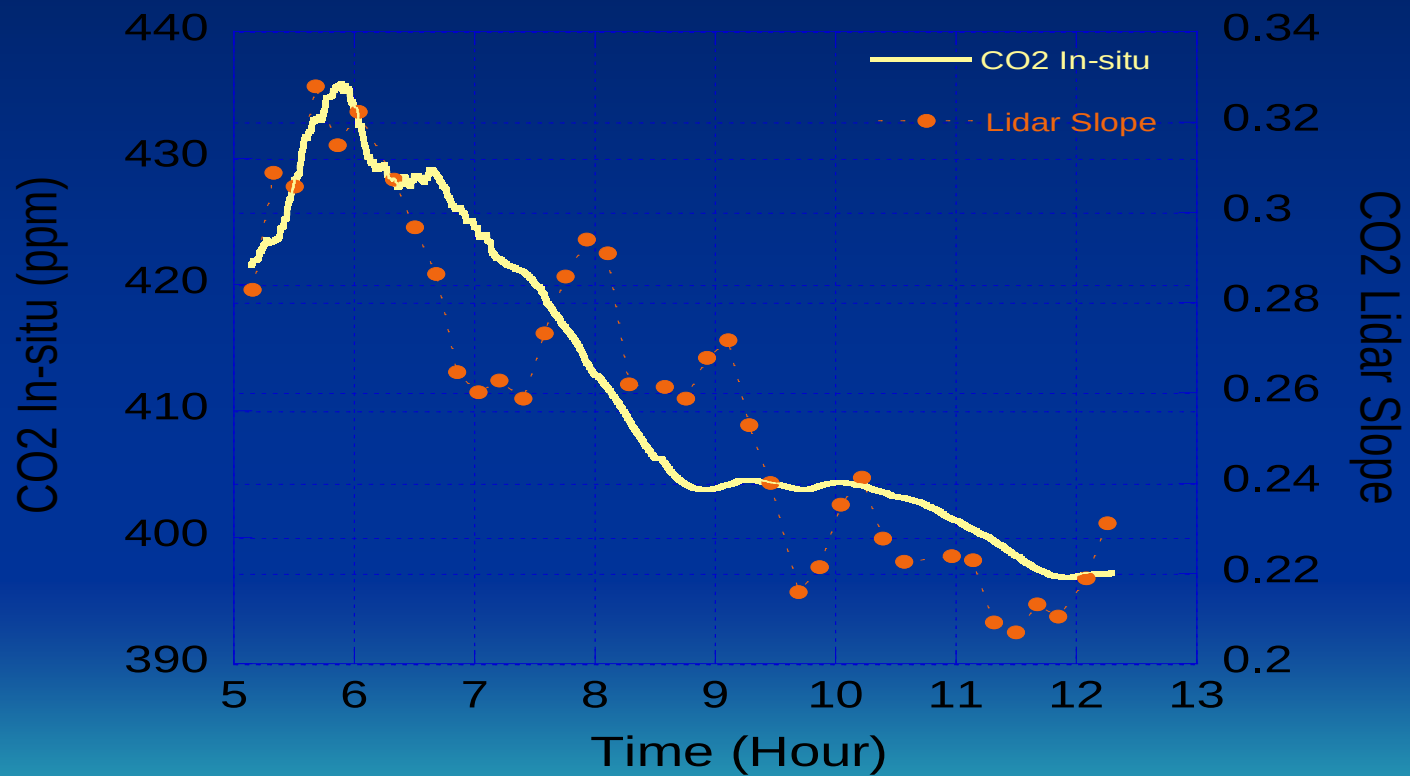
Channel 1 - Heterodyne Signal



Channel 3 - Pulse Intensity



Lidar Measurements



Summary

- LaRC has successfully developed a 2-micron pulsed coherent DIAL, and demonstrated ground based measurement
- For the first time, a unique double pulse laser technique has been used in DIAL, which increase the laser efficiency and improved measurement accuracy
- Accurate laser wavelength control and switching has been demonstrated, which meets the frequency stability and accuracy requirement of the CO₂ DIAL.

